

# Towards Applying the Normalized Systems Theory to IT Infrastructure Systems

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**Abstract.** The agile enterprise requires evolvability at all layers - business, application and infrastructure. IT infrastructure systems are the foundations of IT systems in general. Their evolution has a profound impact on applications and business capabilities. Normalized Systems Theory (NS) provides a method to evaluate the evolvability of modular systems. As IT infrastructure systems can be represented by a modular structure, NS can be used to study their evolvability. An artefact is being proposed, made up of a 4-step method and summary table, to study the evolvability of a modular system representing an IT infrastructure system by means of NS. Although the artefact has been successfully applied to some IT infrastructure systems and as such demonstrating NS can be applied to IT infrastructure systems, the 4-step method requires refinement and a more rigorous translation of the NS theorems into IT infrastructure equivalents. Further research on the subject is being proposed.

**Key words:** IT infrastructure systems, Normalized Systems, modularity, evolvability

## 1 Introduction

The agile and morphogenic enterprise [1] requires the capability to cope with constant change. Business organization, processes, applications and infrastructure need to cope with the required agility.

No application will run without IT infrastructure. IT infrastructure components such as CPU, memory, operating system, are the bare necessities to run any application. Changes and evolutions in the IT infrastructure can lead to serious Combinatorial Effects - hidden coupling or dependencies in a system which increase with the size of the system inducing a ripple effect throughout the whole IT landscape and breaking other IT infrastructure components, applications and even business processes. Architecting and constructing IT infrastructure systems which are resilient to those changes and have proven evolvability, are as important as the creation of applications and business processes which have proven

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evolvability. They are an integral part of the agile and morphogenic enterprise. Normalized Systems (NS) ( see [2] [3] [4] [5]) provides theorems to evaluate the evolvability of modular structures. Using design science, a 4-step method has been worked out to apply the NS theorems to a modular representation of an IT infrastructure system. The artefact has been applied to several IT infrastructure systems, demonstrating the feasibility to apply NS on IT infrastructure systems.

## 2 Proposal

Design science identifies a method, a step approach to address a problem, as a valid artefact to apply to a problem (see [6], [7],[8]). Applying the NS theorems to an IT Infrastructure system has been translated into a method to check the compliance of a relevant modular representation of an IT infrastructure system with the 4 NS theorems, being:

1. **SoC** : Separation of Concerns
2. **SoS** : Separation of State
3. **VT** : Version Transparency
4. **IT** : Instance Traceability

The proposed artefact contains the following steps:

- **Step 1:** Create a relevant modular representation of the IT Infrastructure system.
- **Step 2:** For each module of the modular representation look for manifestations of Concern, State, Version and Instance.
- **Step 3:** Check if the manifestations found in Step 2 are compliant with the 4 NS principles.
- **Step 4:** If there is non-compliance with one or more of the 4 NS principles, describe related Combinatorial Effects (CE).

The results of the 4 steps can be represented in the following summary table:

Infrastructure System	Concern	State	Version	Instance
Module 1				
Module 2				
Module 3				
Module 4				

Compliance	SoC	SoS	VT	IT
NS theorems respected Y/N	Y/N	Y/N	Y/N	Y/N

Observed CE	1. CE1	1. CE1	1. CE1	1. CE1
	2. CE2	2. CE2	2. CE2	2. CE2
	2. CE3	2. CE3	2. CE3	2. CE3

Fig. 1. Artefact summary table

The artefact can also be used in the opposite direction, meaning that based on observed Combinatorial Effects (CE), the violation of one or more of the NS principles can be identified and this violation can be associated to a manifestation of Concern, State, Version and Instance in a module representing a function and/or construction component of an IT infrastructure system.

### 3 Evaluation

In [9] the artefact has been applied on 3 IT infrastructure systems, being Housing (data center setup), Hosting (server hardware and an Operating System) and Proxy (network proxy for N to 1 outbound network traffic). For Housing, Hosting and Proxy, respectively 3 (Housing 1.0, 2.0 and 3.0), 2 (Hosting 1.0 and 2.0) and 1 implementation patterns have been investigated, resulting in 6 effective use cases on which the artefact has been applied.

These 6 use cases have been evaluated by an expert team (13 members) which represent the Knowledge Base in the Design Science framework of Paul Johansson and Erik Perjons [6]. The expert team has been requested to evaluate the correctness of the used IT infrastructure modular structure (step 1 for each of the 6 uses cases), the correctness of the analyses (steps 2 to 4 for each of the 6 uses cases), and score the relevance of the artefact (did it provide additional insight for each of the 6 uses cases). The results can be found in Fig 2.

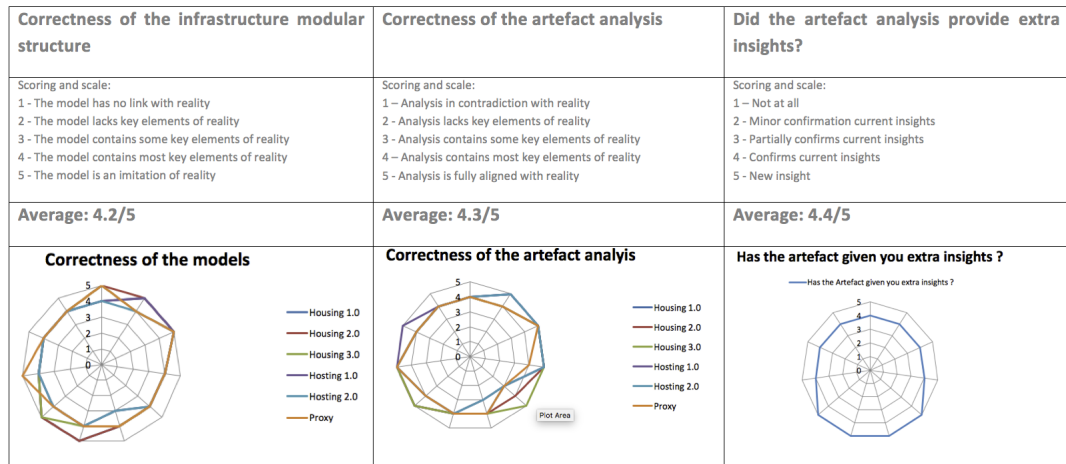


Fig. 2. Artefact evaluation results

## 4 Conclusion and further research

The previous section shows that the proposed artefact can be used to apply NS on IT infrastructure system, and can thus be used to test evolvability of the IT infrastructure system. However, the different steps of the artefact method do require extensive knowledge of the IT infrastructure system under investigation and a good understanding of what the manifestations of Concern, State, Version and Instance may look like in the IT infrastructure system.

Further research is required to create a standardized meta model which can be used to make a modular representation of an IT infrastructure system. A deeper understanding of the meaning of Concern, State, Version and Instance in an IT infrastructure system needs to be further investigated. Based on this deeper understanding, the transformation of the 4 NS theorems into applicable Normalized Infrastructure Systems Theorems (NIST) can be created. The current artefact summary table must be improved by having a standardized way to describe manifestations of Concern, State, Version, Instance and the description of the CE. The proposed artefact improvements will lead to a more systematic approach in applying the artefact.

Once a transformation of the 4 NT theorems into applicable Normalized Infrastructure Systems Theorems (NIST) is available, the research can shift towards using those as input for an expander which will, based on a standardized functional description of an IT infrastructure system, expand code which can be deployed on a Software Defined Infrastructure Platform (like AWS, Azure, Google), resulting in deployable and evolvable IT infrastructure systems.

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